



交叉熵

主讲人：龙良曲

Why not MSE?

Label	predict	correct
3	[0.3, 0.3, 0.4]	yes
2	[0.3, 0.4, 0.3]	yes
1	[0.1, 0.2, 0.7]	no

0.54

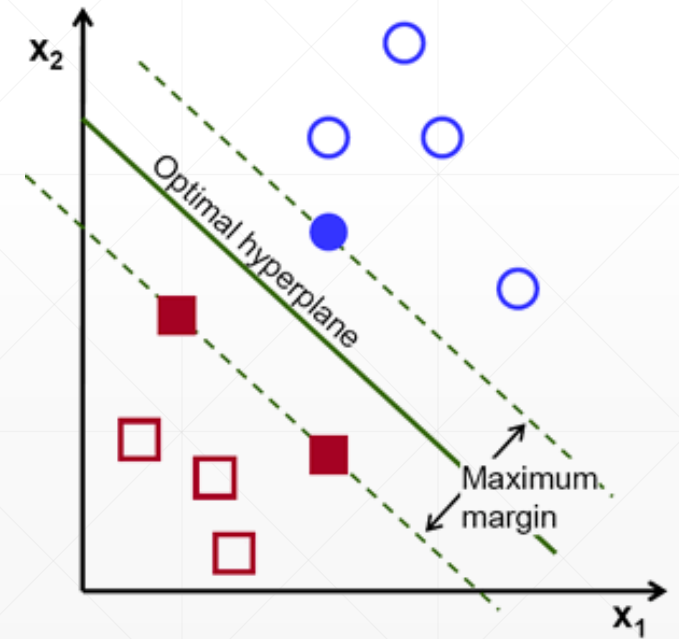
Label	predict	correct
3	[0.1, 0.2, 0.7]	yes
2	[0.1, 0.7, 0.2]	yes
1	[0.3, 0.4, 0.3]	no

0.34

Loss for classification

- MSE
- Cross Entropy Loss
- Hinge Loss

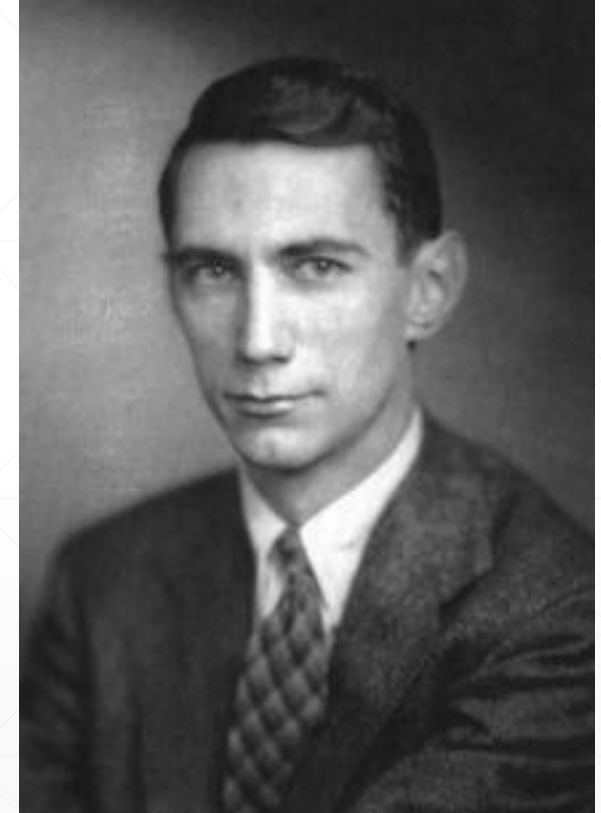
$$\sum_i \max(0, 1 - y_i * h_{\theta}(x_i))$$



Entropy

- Uncertainty
- measure of surprise
- higher entropy = less info.

$$Entropy = - \sum_i P(i) \log P(i)$$



Claude Shannon

Lottery

```
● ● ●

In [2]: a=torch.full([4],1/4.)
tensor([0.2500, 0.2500, 0.2500, 0.2500])

In [4]: a*torch.log2(a)
Out[4]: tensor([-0.5000, -0.5000, -0.5000, -0.5000])

In [6]: -(a*torch.log2(a)).sum()
Out[6]: tensor(2.)

In [7]: a=torch.tensor([0.1,0.1,0.1,0.7])
In [8]: -(a*torch.log2(a)).sum()
Out[8]: tensor(1.3568)

In [15]: a=torch.tensor([0.001,0.001,0.001,0.999])
In [16]: -(a*torch.log2(a)).sum()
Out[16]: tensor(0.0313)
```



Cross Entropy

$$H(p, q) = \sum p(x) \log q(x)$$

$$H(p, q) = H(p) + D_{\text{KL}}(p|q).$$

- $P=Q$
 - cross Entropy = Entropy
- for one-hot encoding,
 - entropy = $1 \log 1 = 0$



Binary Classification

$$H(P, Q) = -P(cat) \log Q(cat) - (1 - P(cat)) \log(1 - Q(cat))$$

$$P(dog) = (1 - P(cat))$$

$$\begin{aligned} H(P, Q) &= - \sum_{i=(cat, dog)} P(i) \log Q(i) \\ &= -P(cat) \log Q(cat) - P(dog) \log Q(dog) \\ &= -(y \log(p) + (1 - y) \log(1 - p)) \end{aligned}$$

for example



$$P_1 = [1 \quad 0 \quad 0 \quad 0 \quad 0]$$

$$Q_1 = [0.4 \quad 0.3 \quad 0.05 \quad 0.05 \quad 0.2]$$

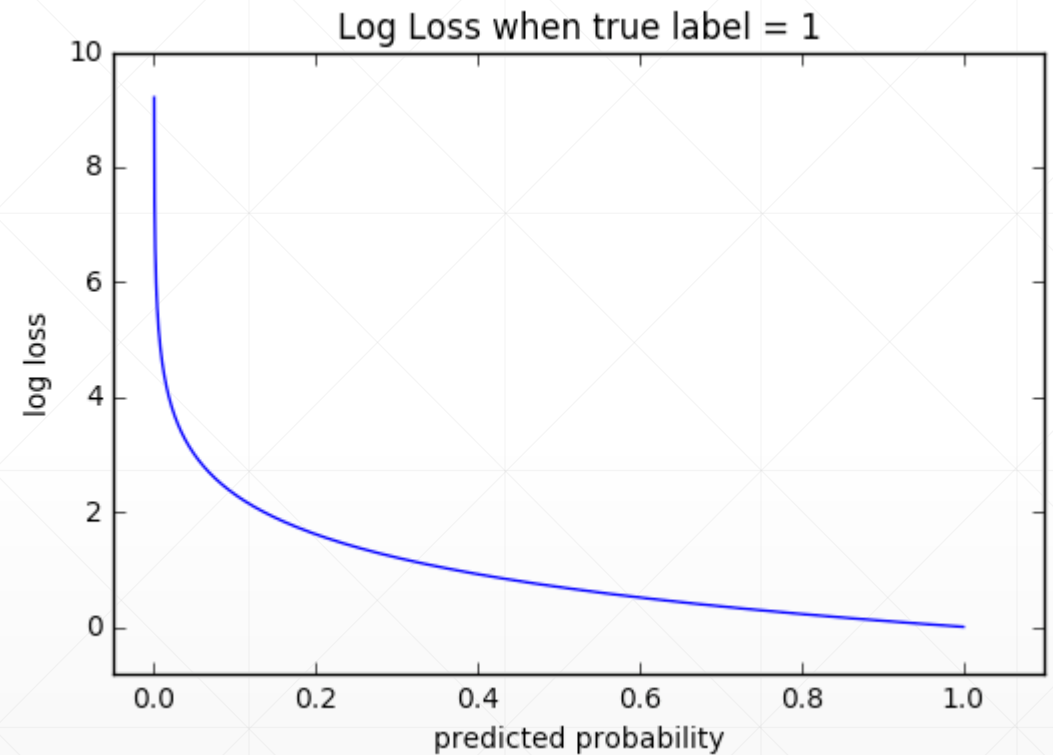
$$\begin{aligned} H(P_1, Q_1) &= - \sum_i P_1(i) \log Q_1(i) \\ &= -(1 \log 0.4 + 0 \log 0.3 + 0 \log 0.05 + 0 \log 0.05 + 0 \log 0.2) \\ &= -\log 0.4 \\ &\approx 0.916 \end{aligned}$$

$$Q_1 = [0.98 \quad 0.01 \quad 0 \quad 0 \quad 0.01]$$

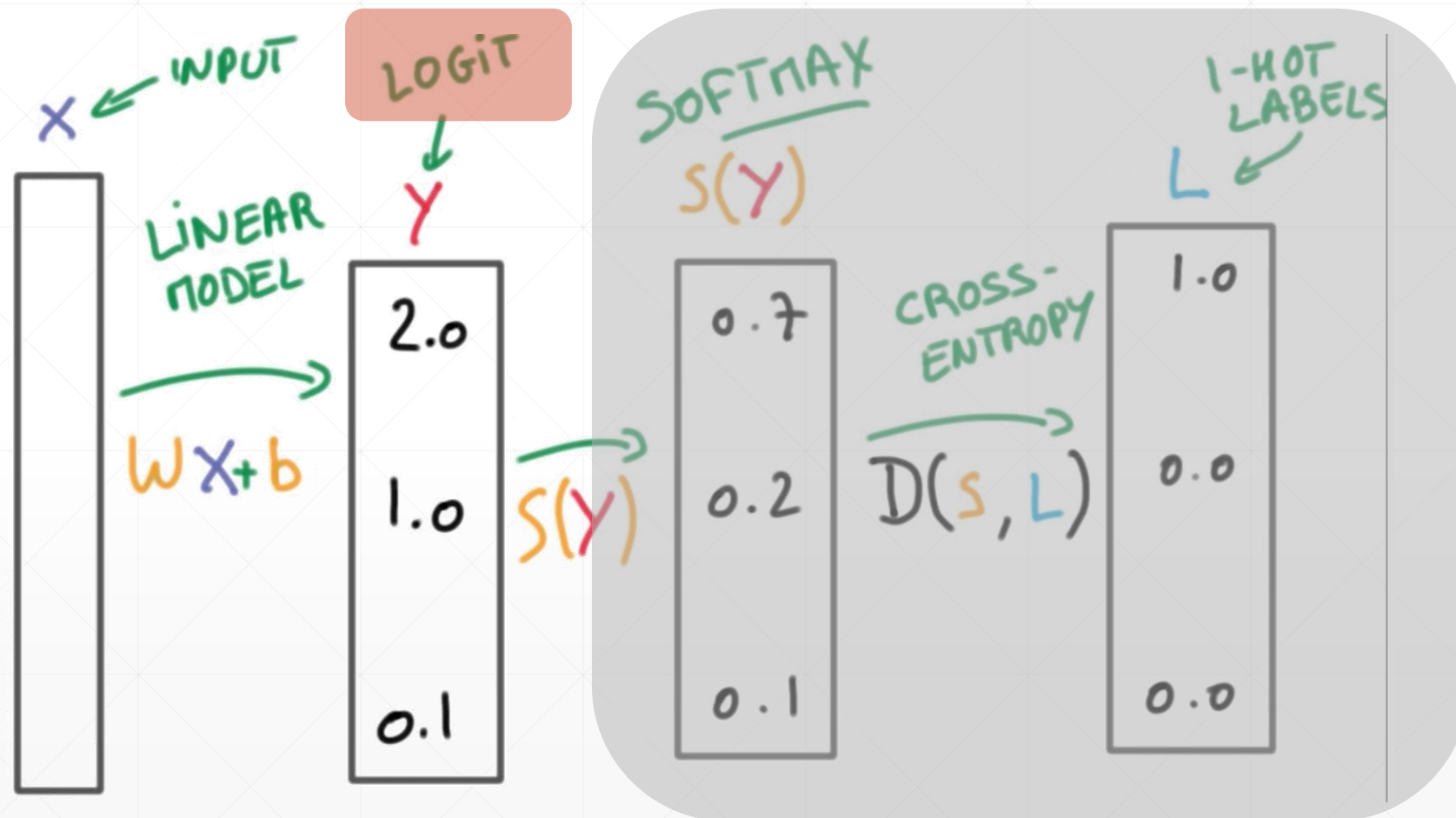
$$\begin{aligned} H(P_1, Q_1) &= - \sum_i P_1(i) \log Q_1(i) \\ &= -(1 \log 0.98 + 0 \log 0.01 + 0 \log 0 + 0 \log 0 + 0 \log 0.01) \\ &= -\log 0.98 \\ &\approx 0.02 \end{aligned}$$

why not use MSE

- sigmoid + MSE
 - gradient vanish
- converge slower
- But, sometimes
 - e.g. meta-learning



Therefore



Numerical Stability



```
In [17]: x=torch.randn(1,784)
```

```
In [18]: w=torch.randn(10,784)
```

```
In [19]: logits=x@w.t()
```

```
Out[20]: torch.Size([1, 10])
```

```
In [34]: pred=F.softmax(logits, dim=1)
```

```
Out[37]: torch.Size([1, 10])
```

```
In [40]: pred_log=torch.log(pred)
```

```
In [41]: F.cross_entropy(logits, torch.tensor([3]))
```

```
Out[41]: tensor(82.4905)
```

```
In [42]: F.nll_loss(pred_log, torch.tensor([3]))
```

```
Out[42]: tensor(82.4905)
```

下一课时

实战多分类问题

Thank You.
